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GETTING STARTED: PLANNING FOR THE DEVELOPMENT OF A PM-2.5 INVENTORY

Air quality management requires a detailed understanding of the local and regional processes that result in high ambient concentrations of the target pollutants. That understanding serves as the foundation for a comprehensive plan to reduce the relevant emissions magnitudes to levels that will result in acceptable ambient air quality. In nearly all cases, that planning effort is based on modeling analyses. While there are many technical considerations that affect the design of modeling scenarios and the interpretation of modeling results, emissions data are one very important input to those models. An accurate and comprehensive baseline emissions data set, resolved to be consistent with the controlling meteorological scenarios, is needed to evaluate model results against current and historical ambient air quality measurements. Meteorological data representative of the appropriate conditions that give rise to high ambient concentrations are also critical for these analyses. Future-year inventories are required to test the net effects of population growth, industrial growth, and source-specific control measures.

In most locations, ambient measurements of PM-2.5 include a significant mass fraction of secondary particulate. In the east, ammonium sulfate is the primary component of secondary particulate. The SO_2 precursor for sulfate formation comes primarily from power plants and other coal-fired and oil-fired boilers, and the ammonia precursor is emitted largely from agricultural activities. The sulfate precursors interact under typical large scale meteorological conditions found in the east to produce a relatively uniform regional contribution to PM-2.5. The nitrate aerosol precursor NO_2 arises primarily from transportation and energy generation sources The nitrate components represent a somewhat larger fraction of the ambient PM-2.5 in the west, than in the east, but the distribution is fairly uniform within the regional areas. Primary emissions of carbonaceous particles from motor vehicles, biomass burning, and industrial sources are likely to make up the bulk of the controllable PM-2.5 in many areas. Although primary particle emissions can contribute to regional PM-2.5 distributions, the effect of primary emissions on air quality are more likely to be dependent on local influences of source mix, meteorology, and terrain features than are the major secondary components.

Source apportionment models and dispersion models can be used to identify and prioritize the most important sources affecting an area and to determine the relative contributions of those sources to the ambient mass loadings. Once the major source contributions are known, an effective control strategy can be developed. Source apportionment and dispersion modeling studies will be most useful to evaluate contributions and to identify control options for local sources.

It is likely that regional modeling analyses will also be necessary to track the large-scale transport processes and chemical transformations that result in secondary aerosol. Regional modeling is also necessary to provide boundary conditions for modeling local sources in subregional-level planning. The regional modeling studies will provide an understanding of the interrelationships among different primary sources and sources of precursors to secondary particle formation. That level of understanding is necessary to develop effective control strategies for PM-2.5 in most areas. Emissions data need to be spatially resolved into a grid cell system, temporally allocated to hourly values, and chemically allocated into the individual species that interact in the controlling chemistry before they can be used as input for these air quality models.

One approach that has been used to evaluate large scale regional air quality issues involves nested modeling. In this approach, the modeling spatial resolution begins with a relatively coarse grid size of up to 80 km on a side. The spatial resolution is increased in steps for subregions that surround the planning area. The most detailed level of resolution is frequently a grid system as small as 2 km on a side to describe the urban area. Each level of resolution is used to provide boundary conditions for the smaller scales and to account for the main large scale emissions and meteorological influences that effect the local area. The region included in the most coarse grid system can extend over an area with dimensions of 1,000 km on a side and can include several States.

These analyses will be similar in nature to investigations of the large scale influences of small particles on regional haze on the Colorado Plateau that were completed by the Grand Canyon Visibility Transport Commission (GCVTC). For States east of the Mississippi River, the efforts to evaluate the effect of regional NO_x emissions on ozone concentrations that were completed for the Ozone Transport Assessment Group (OTAG) is an example of this kind of analysis. Discussions of these programs that describe the planning that went into them and the conclusions that were developed can be found at the following Internet sites:

http://www.epa.gov/ttn/otag/
http://www.nmia.com/gcvtc/

Air quality management plans are composed of many different parts. While each of these parts is linked to emissions data, inventories that differ in detail in terms of source specificity, pollutant specificity, spatial coverage, and timing can be applied to different planning activities. This section discusses some of these issues from the perspective of assessing

priorities for inventory development and gives some ideas of the principal issues that might influence inventory preparation. Whenever possible regional or geographical influences will be discussed to assist in identifying specific planning issues that will effect spatial and temporal scales for inventories in different parts of the country. The following discussion addresses influences that effect spatial and temporal scales separately. This organization is used only to simplify the presentation of the important issues, and the reader should understand that these two influences act together to control the emissions characteristics in myriad ways. This is particularly true in PM-2.5 planning since certain spatial influences operate within specific temporal regimes. The combined effects of the spatial and temporal influences can have quite different results when planning in response to high 24-hour concentrations or for high annual concentrations.

4.1 ASSESSING PRIORITIES

This report has pointed out some of the interrelated issues that will affect planning activities for developing PM-2.5 inventories. The variable origins of PM-2.5 will present challenges for effective planning to address the range of sources that influence PM-2.5 concentrations. While some of the sources of PM-2.5 can be treated with refinements to the approaches historically used in PM-10 planning, there are additional area sources of PM-2.5 and the precursors to PM-2.5 that have not been important in any planning activities completed previously. For example, PM-2.5 planning will require comprehensive estimates of emissions of NH_3 to understand the processes leading to secondary particle formation. It will also be useful to differentiate between elemental and organic carbon from primary PM sources to support regional haze programs, as well as for use in receptor modeling analyses. Initially, States will have to prioritize efforts and focus on the causes of high PM-2.5 concentrations in their State and other affected nearby States, and the sources that can be controlled.

EPA anticipates that the majority of planning activities will focus on the causes of and control of sources that result in high annual concentrations of PM-2.5. Emissions estimates may need to be developed with monthly resolution to address the strong temporal influences that affect sources of PM-2.5 and precursors to PM-2.5. In local areas, additional processes that vary over shorter time scales might also be important; therefore, additional temporal resolution may be required in some areas.

While it is expected that there will be common contributions to the PM-2.5 problems in all areas, it is almost certain that different States will identify different basic scenarios that result in the high measured concentrations of PM-2.5. Planning to address these problems will be facilitated by continuing a partnership between EPA and the States and among the States. EPA will be providing tools to assist in the analyses of sources and emissions that are ubiquitous. Each State will have to develop its own tools to address the specific local influences. States should explore opportunities to share the results of their work with each other so that each State will not have to expend limited resources on all of the possible

problems. To that end, each State should focus on developing tools and improving the activity data, emission factors, and/or emissions estimation methodologies for the important sources in their local planning areas that can be controlled to help reduce ambient concentrations. The application of the National-level tools being developed by EPA, other methodolgies and emission estimation tools developed by other States, and any specific tools developed within each State will provide resources to begin the planning process. It is recognized that as the program develops and the collective experience in PM-2.5 inventories matures, additional refinements and improvements in the inventory development will be available.

4.1.1 Use of Ambient Data to Establish Priorities

A review of all available ambient monitoring data can often provide insights that can help establish planning priorities while emissions inventories are being prepared and adjusted during the initial planning efforts. Initially, ambient data can be applied intuitively to evaluate conditions that affect a given area. Preliminary applications of ambient data are discussed briefly here, while more formal applications involving source apportionment modeling are discussed later in this report.

Currently, ambient PM-2.5 and composition data are limited. The monitoring network using the reference method for ambient PM-2.5 is being established and results from those monitors will become available in the near future. These data can be useful to develop an overview of the spatial and temporal patterns of PM-2.5 in particular areas. Comparison of these patterns with the distribution and operating schedules of the known sources of PM-2.5 can help establish high priority emissions categories that are important on both the local and regional scales. As a simple example, high PM-2.5 concentrations in the winter might indicate that residential wood combustion is an important source, while high concentrations in the summer might lead to the conclusion that other open burning sources, like field burning or prescribed burning, are important.

Some of the samples from the ambient PM-2.5 monitoring network will be analyzed for components. As these speciated data become available, patterns associated with ambient samples and the likely sources that contribute to the ambient concentrations can be refined. It will be possible to draw conclusions about the relative contributions of mobile, industrial, and combustion sources. When a sufficient amount of high quality data are available, these types of analyses will lead to the identification of the principal sources that should be used in more rigorous source apportionment type modeling. As the monitoring record gets larger it will represent more of the conditions that control PM-2.5 formation, and the preliminary analyses can be refined to reflect that improved understanding of the nature and causes of high PM-2.5 concentrations.

It is not necessary to wait until there are several years of monitoring data available to begin this process. There are significant opportunities to begin these evaluations to help set

priorities early in the monitoring program. Even the appearance of the filter can help understand some of the gross features of the primary sources. A very black appearance would indicate that elemental carbon is dominant while a grey appearance would suggest that other origins of PM-2.5 are present in significant quantities. More information on planned activities related to the collection, analysis, and applications of ambient data on PM-2.5 and its precursors can be found at the following Internet page. This page also includes an extensive list of researchers interested in PM-2.5 issues with an emphasis on ambient monitoring and source apportionment.

http://capita.wustl.edu/PMFine/

4.1.2 Use of Emissions Data to Identify Potential Key Sources

Ambient PM-2.5 concentrations in many areas could result from ubiquitous sources that are found throughout the country (e.g., automobiles and stationary fuel combustion) and certain specific local industrial or commercial sources that are unique in a particular area. In many cases, it will be possible for planning agencies to identify possible missing or poorly represented sources by assessing the existing draft emissions inventory of PM-2.5 and its precursors available through the 1996 NET inventory and in periodic updates that are planned for that database.

The NET inventory is focussed necessarily on sources that are known to be of importance nation-wide. That inventory is also based largely on source categorizations and activity data estimates that have been applied for planning activities associated with other criteria pollutants. The NET and other databases that have developed for regional programs, such as the Grand Canyon Visibility Transport Commission (GCVTC), Southern Appalachian Mountain Initiative (SAMI), and the Ozone Transport Assessment Group (OTAG), can be reviewed to determine the completeness of source activities represented in those databases and the applicability of the activity data and emissions estimates to future PM-2.5 planning exercises. States are encouraged to review these databases to determine if there are significant local and unique source categories that are poorly represented in those databases.

This type of information will help States prioritize their efforts on collecting information that they can use to supplement those National-level or regional-level data. States should consider programs to develop source speciation profiles, spatial and temporal allocation factors, and activity data, in addition to, emission factors and other process characteristics that affect emissions.

4.2 DETERMINING APPROPRIATE SPATIAL SCALES FOR INVENTORIES

Assessment of the limited PM-2.5 ambient monitoring data leads to the observation that PM-2.5 air quality in different regions often results from different combinations of influences. There are certainly contributions to PM-2.5 air quality that are ubiquitous (e.g., carbonaceous components from diesel engines), but there are also significant contributions to PM-2.5 that vary on local and regional scales. An obvious example of a local influence is residential wood burning. For example, wood burning for residential heating will affect ambient PM-2.5 in many suburban and rural areas. An example of a regional influence is the observed contribution of ammonium sulfate that contributes roughly 50% of the ambient PM-2.5 in most samples in the east, but only 20% or less throughout the west. States should review all of the data that is available to understand the origins of PM-2.5 in their areas during periods of high ambient concentrations. Then States can begin a preliminary assessment of the sources of both primary PM-2.5, including the condensable components, and the precursors to secondary PM-2.5 that are important in those areas. Some of the spatial influences that need to be considered when preparing a plan to develop emissions data for PM-2.5 are summarized in Table 4.1.

A critical concern relative to spatial influences is to prepare emissions estimates with spatial resolution that is consistent with the air quality problem(s) affecting the area. For example, some areas may experience high 24-hour concentrations that are affected by residential wood burning. This type of problem can often be confined to limited spatial scales within a mountain valley. The inventory to support analyses of such a problem needs to be resolved within the valley. An emissions inventory technique that calculates a county-wide emissions estimate will not provide the information necessary to evaluate the conditions within the valley. This is particularly true in the west where counties often cover very large areas. In this example, the regional contributions to the problems can be handled with coarse resolution, but local influences will have to be characterized at finer spatial detail.

In some cases, emissions data may need to be prepared at varying spatial resolution to develop a complete understanding of the relative contributions of the different causes of PM-2.5. The analyses to understand these complex issues may rely on more than one modeling approach. Inventories with fine spatial resolution can often be aggregated to represent coarser spatial resolution for input into larger scale modeling exercises without introducing significant bias. The reverse process will almost always introduce bias and uncertainty when inventories with coarse spatial resolution are used to derive a more spatially resolved inventory using surrogate distribution factors such as population or land use factors.

Some of the activity data associated with PM-2.5 sources are related to land use or other geographic features that are unrelated to county or other geopolitical boundaries. Examples include acreage in various types of agricultural use, forested areas, and animal husbandry

TABLE 4.1 SPATIAL INFLUENCES IN PM-2.5 PLANNING

Source Category	Type of Emissions	Spatial Concerns		
		Modeling	**Terrain**	**Transport**
Fossil Fuel Combustion - Stationary Sources	Primary and condensable emissions, and precursors to secondary PM-2.5	Regional modeling applications; Primary PM-2.5 may be used in local modeling	Terrain not important in regional applications, may be important in local applications	Secondary precursors can be transported over considerable distances, emissions mainly released from tall stacks
Industrial Sources	Primary and condensable emissions	Regional modeling applications; Primary PM-2.5 may be used in local modeling	Terrain not important in regional applications, may be important in local applications	Not generally as important for long range transport as are utility sources; Emissions are sometimes transported down valleys with typical diurnal valley flow regimes
Agricultural Sources	Ammonia is involved in the formation of secondary PM-2.5	Important for Source apportionment modeling	Terrain and surface features can prevent emissions release to transport layers, local feature concentrate pollutants	Fire, dust and other emissions likely to be local influence; deposition is important issue that needs additional study
Mobile Sources	Primary and condensable emissions and precursors to secondary PM-2.5	Important on both regional and local scales	Urban canyon effects and inversions concentrate soot	Important in regional modeling and secondary aerosol formation, local sources can be concentrated in urban areas
Fugitive Dust	Primary emissions	Mainly of concern for local modeling	Terrain and surface features can prevent emissions release to transport layers, local feature concentrate pollutants	Mostly of concern in local transport; deposition is important issue that needs additional study
Other Combustion	Primary and condensable emissions and precursors to secondary PM-2.5	Important on both regional and local scales	Terrain effects can be significant	Emissions from open fires can transport over very large distances, but can also be very significant on local scales; deposition is important issue that needs additional study

activities. Often it is convenient to organize and manipulate this type of activity data using geographic information systems (GIS). When such data are already available in GIS format, States should consider ways to use those data in their planning efforts. It is usually relatively simple to aggregate such data to be consistent with more standard geopolitical features to facilitate other analyses associated with air quality management programs.

Several of the sources listed in Table 4.1 are identified as significant local sources of primary and condensable components of PM-2.5. Most of these local sources result in emissions that are released close to the surface. In all cases, when these types of sources are located in river valleys or in basins surrounded by mountains, those primary PM-2.5 emissions and surface emissions of secondary precursors will concentrate under conditions with limited mixing volumes caused by temperature inversions. Once the inversions break and the area is ventilated, those trapped emissions can be transported downwind to contribute to regional problems. In any given area, any measured high concentration of PM-2.5 will likely be the result of the combined contributions from local sources and regional processes. The important issues for each specific area must be determined from analyses of all available information. The types of information that will be useful to begin this assessment include the preliminary inventory of primary emissions of PM-2.5 for each county that was developed as part of the periodic emissions inventory process (NET 1996), available ambient monitoring data, and characterizations of visibility reducing conditions that affect any given area.

4.3 DETERMINING APPROPRIATE TEMPORAL SCALES FOR INVENTORIES

Temporal factors can influence planning efforts in several ways. Perhaps the most important temporal consideration is whether analyses are completed to address 24-hour concentrations, annual concentrations, or both. In most urban locations, it is almost certain that multiple emissions scenarios will be responsible for high annual concentrations. For example, there could be different causes of high PM-2.5 concentrations in summer and winter months, and both seasons contribute to annual average concentrations. It is also possible for high 24-hour concentrations to occur at different times of the year and be related to quite different origins of PM-2.5. In these cases, the inventory development effort will have to address each of the potential sources contributing to high concentrations.

Planning efforts to address high 24-hour concentrations will require inventory data that are resolved to hourly levels for those conditions that result in the high concentrations. The hourly inventory might need to also reflect a particular seasonal condition or a specific set of meteorological conditions (e.g., hot, dry, and stagnant meteorology). Planning for high annual concentrations will likely require inventory resolution that reflects seasonal variability. Monthly resolution is recommended for these applications. Frequently, strong persistent low-level temperature inversions are accompanied by low surface winds and minimal advection. These conditions, which trap pollutants near the surface, are generally

more common during the winter months than at other times of the year. On the other hand, sources of secondary particle precursors may have a greater effect during the summer months when meteorological conditions favor deep mixing and photochemical activity. In addition, there are conditions that vary seasonally and diurnally that simply favor higher than normal emission rates of PM-2.5 and important precursors to PM-2.5. For example, emissions from unpaved roads and construction activities will increase during periods that are both dry and windy relative to emissions under wet and calm conditions. All of these considerations must be included in the preliminary planning for inventory development.

Some of the temporal influences that might affect inventory development are listed in Table 4.2. Most of the issues that influence 24-hour concentrations are related to local sources, while planning analyses of annual average concentrations must also consider the regional influences of secondary particle formation.

4.4 PREPARING TO COLLECT DATA

Once the priorities have been established, States can plan to obtain assistance from the affected sources or trade associations that represent the affected sources. New or refined approaches for developing emissions estimates should take advantage of all readily available data related to specific processes and activity levels. Surveys are a preferred method to develop activity data for several of the area source categories that are important in PM-2.5 planning. For example, sources such as residential wood burning could rely on surveys of households, while sources such as fertilizer application or prescribed burning can rely on surveys of fertilizer distributors, or public and private land managers, respectively. Another example of source categories that would benefit from locally generated survey data are leaf and trash burning activities. Survey procedures for these types of source categories are complicated by the need to estimate the effectiveness and compliance with local burning bans where such bans exist. While preparing for data collection through surveys, it is important to define the spatial and temporal scales that are of interest in specific planning programs, and to conduct the survey to collect data that is resolved to the appropriate levels. Details on conducting surveys will vary on a case-by-case basis. Recent EIIP documents and other EIIP documents that are available for review at the Internet site below, provide useful information on how to conduct surveys and the type of information that can be collected through surveys. (EIIP, 1997b)

http://www.epa.gov/ttn/chief/eiip/techrep.htm

TABLE 4.2 TEMPORAL INFLUENCES ON PM-2.5 SIP INVENTORY DEVELOPMENT

Source Category	NAAQS	Temporal Scale	Temporal Issues
Fossil Fuel Combustion- Stationary Source	Primarily annual, some 24-hour	Seasonal to Annual	- Hot, humid conditions with deep and active mixing layers, related to ozone season - Potential for emission rates to vary with seasonal electric demand
Local Industrial Sources	Primarily 24-hour	Diurnal	- Local sources of primary and condensable PM-2.5 dependent on actual wind speed, and direction - Some local sources could be dependent on temperature - Potential to concentrate under tight surface temperature inversions.
Agricultural Sources of NH_3	Both annual and 24-hour	Primarily Seasonal	- NH_3 resulting from fertilizer application dependent on season and soil moisture content - NH_3 emissions from livestock production increase with temperature - NH_3 emissions may be deposited near the source onto nearby vegetation when in full leaf
Mobile Sources	Both annual and 24-hour	Primarily Diurnal	- Primary emissions follow traffic density patterns - There are differences between daily emissions (week day, weekend day, etc.)
Fugitive Dust (Emissions appear to be overstated for these sources using current methodologies.)	Both annual and 24-hour	Seasonal	- Some paved road dust dependent on road sanding practices - Road dust dependent on soil moisture content - Construction and other soil disturbance activities dependent on seasonal weather conditions
Other Combustion	Primarily annual	Seasonal	- Residential wood burning is confined to winter months - Biomass combustion dependent on growing cycles and other seasonal considerations

High priority local sources could be treated as either point or area sources depending on the nature of those sources, the perceived importance of the source categories, and the resources that are available to address those sources. In some cases, it may be possible to develop a representative emissions estimate by using an existing activity indicator, while in other cases, it may be necessary to acquire new data to represent the activity rates for some unique sources. States should review all possible information and recognize that appropriate data to represent the source activity may be available through other regulatory or economic programs that are not related directly to the air quality management agency.

4.5 SUMMARY

For sources that rank low on the priority scale, initial emission estimates based on National-level methods and activity data available through the ASEM will suffice. Similarly, for low priority point sources simple size distribution functions included in *AP-42* (Compilation of Emission Factors) can be used to relate PM-2.5 emissions to PM-10 emissions. Other estimation methods for low priority sources could include the application of per capita or per employee factors, or land use factors that are based on National-level activity data. Estimates based on that level of detail may be sufficient to treat the sources that are not large emitters and can not be controlled to levels that would be of use in the control strategy. Therefore, resources should be concentrated on developing reliable activity data, and in improving the emission factors and estimation methods for those sources that contribute significant emissions and can be controlled with identifiable technology at acceptable costs. Some of the steps that can be taken to develop priorities are discussed below.

- Review all available ambient monitoring data including speciated samples to get an understanding of the principal causes of PM-2.5 that affect the expected planning areas. For example, rank likely local sources resulting from transportation, open burning, residential wood burning, fugitive dust, industrial sources, etc., relative to the contribution from regional secondary aerosol. The inventory development plan may require coordination with nearby States in addition to collection of activity data and the development of emission factors for the local sources.
- Review the draft inventory data for counties in the expected planning area and establish a ranked list of the main contributions of primary PM-2.5.
- Rank the sources of the main precursors of PM-2.5 represented in the draft inventory in a similar way.Identify important sources that affect the area that need new or improved emission factors, size distribution factors, new or improved sources of activity data, etc., to support the planning effort.
- In the near term, States can begin to identify contacts, locate pertinent sources of activity data, and start developing an inventory preparation plan with schedules.

- Develop a plan and the instruments necessary to conduct surveys of the activity data for relevant priority sources (e.g., surveys of wood use for residential heating, typical agricultural or prescribed burning activities, or construction activities).
- Review available data on the size distributions and source speciation for the major contributors to PM-2.5 in the expected planning area (size distribution and source composition profiles in SPECIATE, previous chemical mass balance (CMB) or other receptor modeling analyses, and in published research papers). SPECIATE is a collection of source profile data and CMB is a source receptor modeling approach. Both of these tools can be found on the EPA Internet site.
- Apply receptor modeling to any available speciated PM-2.5 measurements .
- Evaluate the potential amount of emissions control possible (known control technologies or pollution prevention methods and estimated control cost).

There are several other activities ongoing within EPA and EIIP that are developing tools and information resources for application to PM-2.5 emissions inventory planning. EPA is developing preliminary guidance for PM-2.5 emissions inventories, which will be posted on the CHIEF Internet page in the near future. EPA is also working on the Area Source Emission Model (ASEM) that will collect the area source methodologies into a consistent system. EPA is also working on updating, expanding and improving the SPECIATE database and system. As source profiles for PM-2.5 are identified, they will be added to the SPECIATE system. EPA and EIIP are also developing a webpage to serve as a central PM-2.5 Inventory Resource Center. This webpage will provide important summary information and will direct users to other useful Internet sites that contain detailed information related to various aspects of PM-2.5 inventory development. The webpage will eventually be accesible through links from the PM-2.5 EIIP webpage and various other pertinent Internet locations.